LETTERS TO THE EDITOR.

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Coleridge's Theory of Life.

THE old subject of the nature of the vital force or vitality having lately been under discussion, allow me to remind some of your readers that Coleridge did not hesitate to enforce his opinion that it came into the domain of the scientific inquirer, and appertained to the other forces in nature. I cannot express an opinion on his theories of the nature of life, but his holding them in any tangible form has had great weight with some persons, in consequence of his being an orthodox Christian, belonging to what is called the religious world, yet he considered that the nature of life was open to investigation like any other natural phenomenon.

I may be allowed to quote a few passages for the information of those who are not familiar with his essay on the "Theory of Life." Coleridge's idea was that physical life is a process or mode of operation, as we recognise under such names as magnetism chemical affinity, for these, he says, by their own properties affect all the results observed in life. "Life supposes a universal principle in nature with a limiting power in every particular animal, constantly acting to individualize and as it were *figure* the former. Thus then life is not a thing—a subsistent hypostasis—but an act and process." "To account for Life is one thing, to explain Life another. To a reflecting mind indeed, the very fact that the powers peculiar to life in living animals *include* cohesion, elasticity, &c. (or, in the words of a late publication) 'that living matter exhibits these physical properties' would demonstrate that in the truth of things, they are homogeneous and that both the classes are but degrees and different dignities of one and the same tendency. Unless therefore a thing can exhibit properties which do not belong to it, the very admission that living matter exhibits *physical* properties, includes the further admission that those physical or dead properties are themselves vital in essence, really *distinct* but in appearance only *different*; or in absolute contrast with each other." "If I were asked for what purpose we should generalise the idea of Life thus broadly, I should not hesitate to reply that were there no other use there would be some advantage in merely destroying an arbitrary assumption in natural philosophy and in reminding the physiologists that they could not hear the life of metals asserted with a more contemptuous surprise than they themselves incur from the vulgar when they speak of the life in mould or mucor. But this is not the case. This wider view fills up the arbitrary chasm between physics and physiology and justifies us in using the former as means of insight into the latter."

The author then proceeds to discuss his argument through the lowest creatures in animal life until he reaches man.

"The arborescent forms on a frosty morning to be seen on a window or pavement must have *some* relation to the more perfect forms developed in the vegetable world." He then alludes to the different classes of animals, and says, "as the individuals run into each other so do the different genera. They likewise pass into each other so indistinguishably that the whole order forms a very network. Man forms the apex of the living pyramid. He has the whole world in counterpoint to him but he contains an entire world within himself."

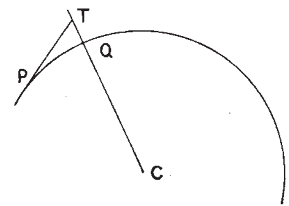
It is clear, therefore, that Coleridge (and others may do the same), whilst holding strictly to the belief in a spiritual existence, yet regarded vitality from quite a different point of view, resulting, indeed, from a combination of forces as we see in other phenomena of nature. SAMUEL WILKS.

Psychophysical Interaction.

SIR OLIVER LODGE says (p. 53) that he would "interfere with the course of nature," regarded as a mechanically determinate problem, even by lifting a log. Why so? The course of nature is exactly what happens, is it not? It is the business of scientific men to find out the course of nature, and the various connections which give it coherence and consistency and determinancy. This has been largely done, even in vital processes: and in the obscurer regions of psychics it seems probable that the course would be determinate if we knew all the circumstances. In any case we have nothing else but the course of nature to go by, in the determination of its laws, and that psychic phenomena are natural phenomena is, it seems to me, the only rational view to take. OLIVER HEAVISIDE.

May 21.

MAY I contribute a pictorial illustration to the controversy raised by Sir Oliver Lodge?



P Q, part of a circular path described by a body of mass m round a fixed centre C, under the influence of a constant centripetal force of magnitude F. Whether this is supplied by a string with a tension F or by an attraction which will be constant if the path is circular does not seem to matter in the least.

Now let P T be the tangential distance which would be traversed in a time t if the centripetal force were absent.

When that force is introduced, P will come to Q instead of to T, and the work done by the force consists of pulling the mass from T to Q in the time t. The energy required to do this is F×T Q, and the same amount is required and absorbed in each successive interval of t. This result is not affected by calling F a guiding force, which it is. If instead of a body describing a circle we had dealt with a body at rest in the position T, the energy required to bring it to Q would be exactly the same.

If Newton had had to express himself (modern fashion) in terms of energy, can we imagine him dealing with the problem except in some such way as my drawing indicates?

Athenæum. G. W. HEMMING.

ATMOSPHERIC ELECTRICITY.

UNTIL within the last two or three years, the advances made in our knowledge of atmospheric electricity were mainly due to the investigation of the electric field of the earth. An interesting summary of the facts brought to light by such investigations will be found in a paper by Exner in "Terrestrial Magnetism and Atmospheric Electricity" (vols. v., p. 167, and vi., p. 1).

Except at or near places where rain (or other form of precipitate) is falling, there is in the free atmosphere an electric field tending to drive positive electricity downwards; the earth's surface is thus in fine weather regions negatively charged. The strength of the electric field and the magnitude of the charge per square centimetre on level ground at a distance from trees or buildings may be found by observing the potential at a measured height. According to Exner, the normal (fine weather) potential gradient in European latitudes varies from about 80 volts per metre in summer to 400 or 500 volts per metre in winter.

It has now been established by means of balloon observations that the intensity of the electric field in fine weather begins to diminish when a comparatively small altitude is reached, and at a height of 5000 metres has only a small fraction of the intensity at the earth's surface. This shows that the lower layers of the atmosphere possess a positive electrification very nearly equivalent to the negative charge on the ground.

For the study of the variations of the electric field at a given place a large mass of material is furnished by the electrograph curves obtained at various observatories. There is a well-marked annual variation in the intensity of the electric field; the maximum occurs in winter and the minimum in summer, the midwinter values being five or six times as high as those of midsummer. The daily variation is less regular, and its character depends on the place of observation and on the season of the year. Three types are recognisable according to Exner. Most commonly there are maxima about 8 a.m. and 8 p.m., with night and noon minima between them. There may, secondly, as on the Eiffel Tower [1] and in winter at many low level stations also, be a minimum in the early morning hours, and a flattened maximum over the day hours. Finally, as in Ceylon and on the Indian Ocean, there may be no daily variation.

A great advance was made in 1899 by Elster and Geitel. They proved, in agreement with previous experiments of Linss, that an electrified body exposed in the open air loses its charge comparatively rapidly by leakage through the air; the leakage is more rapid the clearer and more free from dust the air may be. They showed that the phenomena were entirely in agreement with the supposition that the atmosphere contains positively and negatively charged ions free to move under the action of the electric field. An interesting account of the application of our knowledge of gaseous ions to the explanation of many of the phenomena of atmospheric electricity has been given by Geitel.[2]

Charged conductors exposed in the open air are found to lose 1 or 2 per cent. of their charge or more per minute; the leakage from negatively charged bodies is often somewhat greater than that from positively charged bodies; this difference is especially great on mountain peaks, where a negative charge may be neutralised many times as fast as a positive one, indicating an excess of positive ions. Ebert [3] found in balloon ascents an increased rate of neutralisation in the upper atmosphere as on mountain peaks, but without any marked difference between positive and negative leaks. Many observers, especially in Germany, have lately been carrying out measurements of this "Elektricitätszerstreuung."

There have, however, been very few absolute measurements from which the number of ions present per c.c. in the open air could be determined. Measurements of this kind have been made by Ebert and by Rutherford and Allen. The latter observers found (*Phil. Mag.*, December, 1902) for the number of ions per c.c. of air drawn in from outside their laboratory values which on certain occasions were as low as 30 per c.c., the charge carried by each ion being about 3×10^{-10} electrostatic units, according to recent determinations by J. J. Thomson (*Phil. Mag.*, March) and by H. A. Wilson (*Phil. Mag.*, April). Rutherford and Allen also showed that the velocity of the ions of the free atmosphere under a given strength of field was approximately the same as that of the ions produced by Röntgen and Becquerel rays, being about 1.4 cm. per second for a potential gradient of a volt per cm.; we are probably therefore justified in assuming an identity in other properties also. With the above values for the number of ions and their velocity, the charge on the ground should be neutralised at the rate of about a half per cent. per minute.

In connection with the question of the origin of the ions in the atmosphere, some remarkable phenomena have to be considered. Even in dust-free air in a closed vessel in the dark there is a continuous production of ions, generally at rates not differing greatly from 40 per c.c. per second, if we interpret the measurements in the light of the most recent determinations of the ionic charge. It has, however, been shown by McLennan and Burton,[1] and by Strutt (NATURE, February 19), that the greater part of the effect is due to the walls of the vessel, that ordinary substances in varying degrees resemble radium in being radio-active and producing radio-active emanations, the effects, however, being of incomparably smaller intensity. The two first-named experimenters also found that a part of the ionisation is due to an extremely penetrating radiation from sources outside the vessel. Rutherford and Cooke (NATURE, April 2) have obtained a similar result. Elster and Geitel found that negatively charged bodies exposed in the open air become temporarily radio-active, just as they do when exposed to the emanations from radium or thorium. Vessels in which freshly fallen rain or snow have been evaporated to dryness show a similar temporary radio-activity.[2] The atmosphere apparently contains an emanation like that from radium. Air pumped out of the ground shows these effects to an abnormally marked degree, as Elster and Geitel have proved. The surface of the ground, and to a still greater extent the exposed portions of trees, must, it will be observed, under normal fine weather conditions become radio-active in virtue of their negative charge, and produce, therefore, an abnormal amount of ionisation in the air near them.

It is probable, in the light of Lenard's experiments, that sunlight ionises the air which it traverses, especially in the upper atmosphere, while it is still strong in ultra-violet rays.

The conductivity of the air increases in a sense the difficulty of the problem of the origin of the earth's electric field. For it would seem that the electric field in fine weather regions should rapidly diminish, and in a few hours disappear; there must be some process by which the electric field is continually being regenerated. Leaving aside, however, the consideration of the origin of the electric field, we may attempt to explain its variations as due to the variations in the conditions determining its rate of destruction. Whatever increases the conductivity of the air will diminish the electric field, and *vice versâ*. Examples of the application of this principle will be found in the paper by Geitel already mentioned. To take only one, the increase in the electric field accompanying fogs (a phenomenon well shown in the Kew electrograph curves) may be explained as due to the entangling of the ions by the fog particles; the leakage of electricity under such conditions has been found by Elster and Geitel to be very slight.

In regions enjoying fine weather, if we assume the existence of a flow of electricity in the direction of the electric field, there will be a downward earth-air current; there must then be a compensating current accompanying precipitation, negative electricity being brought down in the rain, and the positive charge being left behind in the atmosphere and carried by upper air currents to other regions. There is, as we shall see later, reason to believe that an excess of negative electricity is brought down to the earth's surface by rain. It is, however, doubtful whether we can explain in this way the existence of the normal electric field at a distance from regions where rain is falling; for the positively charged upper air currents would continually be losing their charges, and we should expect a rapid falling off in the intensity of the field

1 Chauveau, *C.R.*, vol. cxvii. p. 1069 (1893).
2 "Ueber die Anwendung der Lehre von den Gasionen auf die Erscheinungen der atmosphärischen Elektricität." (Braunschweig, 1901.)
3 "Terrestrial Magnetism," vol. vi. p. 97 (1901).

1 In a paper read before the American Physical Society, December, 1902.
2 C. T. R. Wilson, Camb. Phil. *Proc.*, vol. xi. p. 428; vol. xii. pp. 17 and 85; M'Lennan, *Phil. Mag.*, April.

with increasing distance from the region of precipitation.

We may, on the other hand, suppose that there are everywhere other influences opposing or neutralising the ion of electricity in the direction of the electric field; so that no earth-air current results. Geitel has offered an explanation of the maintenance of the electric field in fine weather based on a difference between positive and negative ions which was discovered by Zeleny. Negative ions are more mobile than positive, they travel with greater velocity in an electric field and diffuse more rapidly. In consequence a body exposed to a current of ionised air becomes negatively charged; Geitel suggests that the surface of the earth may acquire its negative charge in a similar way. The difference in the velocities of diffusion of the positive and negative ions could not, however, maintain an electric field except close to the ground, unless air currents were present to carry up the positively charged layers produced at the earth's surface.

It is quite conceivable that we may be driven to seek an extra-terrestrial source for the negative charge of the earth's surface. The study of the aurora borealis has led several observers to the conclusion that the sun emits kathode rays, which are deflected by the earth's magnetic field, and travel in helical paths round the magnetic lines of force towards the poles. It is conceivable that very penetrating rays of this type (*i.e.* negatively charged electrons) may traverse our atmosphere unabsorbed, and be stopped in the solid mass of the earth, giving to it their negative charge.

We have now to consider the electrical phenomena accompanying precipitation. As already indicated, precipitation is nearly always associated with the occurrence of negative values of the potential gradient. Heavy showers of rain, snow, or hail are accompanied by rapid alternations of high positive and high negative values of the electric field, generally too high to be measured by electrograph apparatus arranged to suit fine weather conditions. In extreme cases we have thunderstorms. There are cases of rain not associated with negative potential gradients; these are practically all cases of slight rain, generally mere wet mist or drizzle. Clouds from which rain is not falling rarely show marked electrical effects. To find by direct observation whether rain is charged with electricity is a matter of extreme difficulty. Elster and Geitel's observations appear to show that raindrops are charged, and that the sign of the charge frequently changes during a shower, negative values, however, on the whole prevailing.

The following are possible factors in the production of the intense electrical fields which accompany heavy showers.

A less degree of supersaturation is required to make water condense on the negative than on the positive ions (C. T. R. Wilson, *Phil. Trans.*, vol. cxciii. p. 289). Thus, if condensation takes place from the supersaturated condition, the drops formed are likely to be negatively charged; that the drops, formed in ionised air by expansions slightly exceeding that required to cause condensation on negative ions, are actually negatively charged has been proved by H. A. Wilson (*Phil. Mag.*, April). Since, however, each drop will only carry the very small ionic charge, the electrical effect will be small if only a few large drops are formed; if a large number of negative ions serve as nuclei of condensation, the drops will be small, and will only fall slowly relatively to the air; the resulting electric field cannot exceed that which drives positive ions downwards as fast as the negatively charged drops fall under the action of gravity. The field initially produced may, however, be strong enough to induce coalescence of drops which come in contact (Lord Rayleigh, Roy. Soc. *Proc.* xxviii. p. 406), and we may thus get drops carrying many times the charge of one ion, and large enough to fall rapidly. Strong fields may then result.

Again, we should expect (NATURE, vol. lxii. p. 149) drops falling through ionised air to become negatively charged as a result of the difference in the mobility of the positive and negative ions. This effect has, in fact, been experimentally demonstrated by Schmauss (*Ann. d. Physik*, vol. ix. p. 224).

If collisions resulting in splashing occur between raindrops (and they are likely to be frequent in the uprush of air in thunderstorms), positively charged rain may be formed. For, as Lenard has shown, when splashing of pure water occurs, as, for example, in waterfalls, the air in the neighbourhood acquires a negative, the water a positive, charge.

Apart from the Lenard effect, the splashing resulting from the collision of drops in an electric field may have large effects, either in intensifying or diminishing the electric field already existing, the action being like that of an electrostatic influence machine. The result would be to increase the intensity of the field if the splashes were thrown out from the lower portion of the combined drop. If, for example, the field were such as to produce positive electrification on the lower surface of a neutral drop, a droplet leaving the lower surface would be positively charged, and being carried upwards by the air relatively to the large drop, would add to the intensity of the primary field.

C. T. R. WILSON.

RAINFALL AND RIVER FLOW IN THE THAMES BASIN.[1]

THE Water Committee of the London County Council in December, 1902, called upon their chief engineer for a report on the diminution of the volume of water in the Thames and Lea, and his report was submitted to the Council in February. It deals briefly with the geology of the Thames and Lea basins so far as geology affects waterworks engineering, and in greater detail with the rainfall and the flow of the streams. The general result of the inquiry is thus stated :—

"For the past twenty years there has been a decline over the Thames watershed of an annual average of nearly $2\frac{1}{2}$ inches below the mean rainfall of 28.50 inches, as computed by the late Mr. Symons for the forty years 1850–89; and I may add that this diminution has become more accentuated during the last five years. This decline is reflected in the diminished flow of the river as gauged at Teddington Weir, the natural flow having fallen to an average of $1110\frac{1}{2}$ million gallons daily at the intakes for the 20 years compared with 1350 million gallons over the 1850–89 period, showing a loss to the river of $239\frac{1}{2}$ million gallons per day. As the diminished rainfall of $2\frac{1}{2}$ inches equals 105 million gallons per day (after making an allowance for evaporation, &c., of roughly 70 per cent.), and the above diminished flow of $239\frac{1}{2}$ million gallons shows a difference from this of $134\frac{1}{2}$ million gallons daily, it would appear as though the condition of the river was becoming more acute, inasmuch as more rainfall would be required year by year to produce the long-period average rate of flow; in fact, what this means is that the percentage of total rainfall which reaches the river is diminishing as well as the total rainfall itself. Of course, against these facts we have the possibility of a long series of wet years, which

[1] London County Council. Shrinkage of the Thames and Lea Report by Maurice Fitzmaurice, C.M.G., Chief Engineer. Pp. 18; plates. (London: P. S. King and Co., 1903.)